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ABSTRACT

The first (exploratory) phase of the Learning in Science Project focused on science teaching/learning in the Form 1 to 4 level (ages 10 to 14) and sought to identify problems and difficulties in several areas. Provided in this paper are comments obtained during structured interviews (from students, ex-students, teachers, headmasters, science advisers, and inspectors) and observations made by project staff related to what children bring to their learning of science. The intent in presenting these comments/observations is not primarily to provide a balanced view of the good bad aspects of Form 1 to 4 science, but rather to open up problem issues as project staff and others see them. Comments/observations are presented in three sections, focusing on: (1) differences between what students expect to do and learn in school science programs and what actually occurs; (2) problems students face with abstract ideas and complex experiments, and such difficulties as get ing students to think or follow simple instructions, or their lack of reading/practical skills; and (3) motivational factors, the most important relating to differences in expectations between teachers and learners. Major points are summarized in a concluding section, followed by extracts from interviews related to student expectations, capacity, and success. (JN)

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LEARNING IN SCIENCE PROJECT

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FOCUS ON THE LEARNER

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WORKING PAPER No 6

The Learning in Science Project is an educational research project undertaken at the University of Waikato under contract to the NZ Department of Education. The project is initially investigating the problems and difficulties of Form 1 - 4 Science (10 - 14 year olds) as a first step to improving teaching and learning.

This paper is one of a set of essays which is an outcome of the exploratory phase of the project. It is our hope that feedback from these essays will assist further to clarify issues and assist us in establishing priorities for the in-depth phase of the project. Any comments our readers have on either the issues involved, or the methodology adopted in these papers, would be most welcome.

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FOCUS ON THE LEARNER

A WORKING PAPER OF THE LEARNING IN SCIENCE PROJECT

Peter Freyberg, Roger Osborne and Ross Tasker

September 1979

This is one of a set of discussion papers which focus on various aspects of Form 1-4 Science. The paper collates comments and observations, related to the topic of focus, which were obtained during the first phase of the Learning in Science Project. In this phase we were particularly concerned about problems and difficulties in Form 1-4 Science and because of this the paper is biassed toward issues as identified by pupils, ex-pupils, teachers, headmasters, science advisers, inspectors as well as by our own observers. Our intention in writing the discussion papers is therefore not primarily to provide a balanced view of the good and bad aspects of Form 1-4 Science but rather to open up problem issues as we and others see them, to a limited but wider audience than the project team.

It is our hope that our chosen readers will be prepared to talk to us about the topic under focus in this paper in terms of the following questions:

(i) Are the issues we have raised important and central issues which are of general concern?

(ii) Are there other more basic issues, or other subsidiary questions, about the topic which we have overlooked?

(iii) Which aspects of the topic could we profitably analyze further in the in-depth phase of the project?

(iv) What possible solutions to some of the issues raised could profitably be the subject of further study?

INTRODUCTION

This paper is concerned with what F1-4 children bring to their learning of science : more specifically, it presents (as is the case with all of the Focus papers) the perceptions that various participants or ex-participants have of what happens in school science programmes. Thus it is impossible to avoid some overlap with the content of other working papers in this series, such as those dealing with topics and attitudes in particular, but here we aim to set out to view the main factors which children believe influence the learning process in science as they have experienced it.

Our review will be presented under three main headings :

Expectations versus reality
Some questions of capacity
Motivational factors

Most of the views expressed below are those of the learners themselves, but frequently there were corresponding comments from their teachers and from outside observers.

EXPECTATIONS AND REALITY

Children's ideas of what science consists - and thus of what they might expect to do and learn in school science programmes - are quite diverse, as one would expect.

11/3/2[1] "Most of the kids when they start at intermediate they think science is blowing up things and pulling things to bits... that fascinates kids.... I didn't think pulling plants to bits was science"

[ex-pupil]

16/7/1 "Oh, the kids all thought it was great using proper science equipment, you know like test tubes. You know they liked using the proper equipment because it made them feel more scientific, I suppose, at that age [intermediate school]..."

[ex-pupil]

36/1/1 "...and F2 we moved to the big time and we actually went on a trip. And we did do science - geology and looked all around the Waikato which I actually did in F3 and 4 as well, so it was triple-ly exciting..."

[Form 6 pupil]

[1] Denotes the transcript file from which the quote has been extracted or references a quote which supports the comment made.

Undoubtedly the expectations children have for school science are initially high and may well remain high [see Appendix 1]. The predominant expectation is one of activity - of being able to do things to find out. In practice, however, some pupils seemed to be more concerned with the doing than with the finding out.

24/12/2

"...We went down to the creek and we got animals out of the creek and grass and things like that..."

[Form 3 pupil]

15/10/1

"[Experiments] were good. In the 4th form take the example of Kinematics...the way we did it was really good...we would take our ticker tape and cut it up and make a graph of it..."

[ex-pupil, teacher trainee]

But the realities of F1-4 science teaching for many of them proved somewhat different.

15/3/2

"At the beginning of the 3rd form it was something pretty new and the labs looked pretty impressive and that sort of thing. But we didn't enjoy it much or anything through the year... we had a pretty negative attitude towards it... (What caused that?) I think it was just sit down and learning. You didn't participate in it much... it was pretty hard to grasp some of the things they were giving us, they were pretty new, and then we have tests and exams. and fail at everything..."

[ex-pupil]

36/12/1

"The only practical thing we did [in Form 3] was in the rose community or cabbage community. What we did is everyone is supposed to bring a rose or a cabbage and we dissected [them] to see what we could find what was inside - and that was about it. (What did you find?) Nothing. It was too well sprayed. (A community of none?) We found a slug, one slug in a cabbage, and that was pretty sickly, too....it shows people using too much sprays..."

[Form 2 pupil]

Probably the most pervasive comments from pupils were on the lack of practical work, particularly at the Intermediate level. Many science lessons, by all accounts, consisted of "going for film-strips", or copying diagrams, or writing up experiments out of a book - which seemed to be the most significant recollection of a substantial number of learners.

36/12/1

60/6/1
11/3/3
7/5/1
24/12/3
24/14/1
36/11/1

"They just wrote it on the board and you just wrote it down in your little book...or you copied it out of your science books which meant nothing..."

[ex-pupil]

43/2/1
43/7/1
11/3/1 "...we did a lot of copying of pictures and diagrams and that was pretty useless because it was all right under our nose... You don't learn anything by just writing it down."

[ex-pupil]

75/8/3 "Science [classes are] like cooking [classes]..you go to cooking to cook but instead of it we always write up home management and that..."

[Form 3 pupil]

Children's impressions about the lack of activity in science lessons were confirmed by the comments of a retired secondary inspector:

58/1/1 "This would be the No. 1 problem - Why, what are the difficulties which prevent teachers from letting kids do experimental work? Science is not empirical in schools, there is no doubt about that."

But it seemed to be very much a matter of who the teacher was, even in the Intermediate School

20/24/1
60/7/1 "Last year was fun because we did mostly experiments. The year before that all we did was writing - it was boring."

[Form 3 pupil]

And even where there had been, apparently, plenty of practical work it didn't always bring the hoped-for response from pupils, either by way of increased skills...

15/3/1 "Um...no...I don't know a terrible lot [about scientific procedures]. I still don't know how to go about experiments properly and that sort of thing. You sort of just wrote out methods."

[6F biology pupil]

or improved scientific knowledge or attitudes.

13/3/1
13/5/1 "If we had seen more of the practical applications of it - I would probably have enjoyed it more..."

[ex-pupil, teacher trainee]

24/12/1 "...we didn't do anything - we just mixed things up and wrote things down..."

[Form 3 pupil]

Sometimes the activity itself was interesting but there was apparently little learnt from it.

24/15/1 "...the science teacher did up this tin and he added water to it and it all went inside - all crushed up. That was a good one, when he added cold water to it. (So what did he do? He put a little bit of water in it, heated it up...) No, we just saw him tip the water over it and it all went in - squeezed all up. (Why did it do that?) We don't know."

[Form 3 pupil]

20/26/1 "A lot of people weren't thinking about it - they just treated science as a bit of a game. Other people just didn't understand some of the terms and things like that..."

15/7/3 [Form 3 pupil]

15/1/2
15/5/2
65/12/3
11/1/2
7/2/3 Yet many children wanted to be challenged to think for themselves by undertaking real, albeit minor, investigations. This was not confined to the brighter children either.

15/5/2 "Its good if you can get into it yourself you know and find out these things for yourself and perhaps ask questions why?"

[ex-pupil]

17/13/1
20/11/2
20/19/2
20/25/2
43/2/2
43/12/1
11/2/1 Other impressions which learners have carried on with them bring out difficulties which are common to most teaching situations. Several pupils or ex-pupils commented on boredom in science lessons which came from repeatedly covering the same topic at different class levels, sometimes with contradictory information! Some complained that too much time was spent on a topic, while others that the teacher rushed from one topic to another without giving them time to fully explore it.

11/2/1 "You might be doing experiments in chemistry and physics and you just start to get to know what you're talking about and they change it and do biology because then you forget everything that you know...in the end you don't know what you are doing."

[ex-pupil]

83/2/2
27/7/2
63/3/2
8/4/2 Children also commented on their inability to understand the technical terms used, and even teachers commented on the tendency to resort to technical words in the face of one's own limited knowledge - a not uncommon phenomenon in everyday life!

36/2/1 "...it would have been good if we had known what the words meant before we went out instead of having to come back and write up... we actually had to learn how to spell photosynthesis which took about 4 or 5 weeks to get the whole class to spell it right. But even the teacher couldn't say what photosynthesis meant..."

[Form 6 pupil]

SOME QUESTIONS OF CAPACITY

43/4/1
43/1/1 "I enjoyed doing all the experiments and that. It was fun. But when it came to the theory I didn't like it. I just turned off as soon as that came..."

[ex-pupil aged 15 years]

13/2/1 "I worked really hard to make sure I got a good mark so that I could do [5th form science]. But then they said I didn't have the maths and my maths wasn't good, so I couldn't do it..."

[ex-pupil, teacher trainee]

A second major theme running through the comments of learners about their science teaching was the difficulties they experienced with the theoretical components of the material. This was particularly noticeable

7/4/3
5/4/1
9/9/1

with respect to the physical sciences, where (as above) many were put off by the mathematical calculations required, the equations to be worked out, or the formulae to be remembered.

15/4/1

"(Why did you prefer Biology?) I think it was mainly that I felt biology was easier.
(Why did you think that?) Because there was a lot of mathematical learning in physics and chemistry.
(How was your mathematics?) Oh not too bad and not too good... it never really worried me much...I did 6 Form maths"

[ex-pupil]

It is our impression that a good deal of these difficulties were attitudinal but there is no doubt that the early introduction of formulae and equations has been off-putting to a substantial number of children.

75/5/2

"People get turned off physics for a start because they are told it is the hardest one...that's the reason...the maths also might turn them off it... a lot of kids don't like maths...it doesn't suit them...they don't want to learn all the formulas."

[ex-pupil]

61/4/2

Children also have difficulty with language in general, particularly with comprehending scientific textbooks.

61/4/3

"Oh I can't understand the textbook, it...oh it says something about photosynthesis and down at the back it says something different about it...maybe its me."

[Form 3 pupil]

Another example of this problem of comprehension is given in Appendix 2

Mention has already been made of some of these difficulties which children have with theoretical understanding in FOCUS ON KNOWLEDGE and on the difficulties children have with really understanding what some of the experimental work is all about in FOCUS ON EXPERIMENTS. In the latter paper comment was made, in response to children's statements, that they were never really made to think, that this may have been because the work was really outside their capacities.

58/9/2

"I have a feeling that what they are saying to you [is] 'when they asked me to think it was beyond me'".

[secondary science inspector]

Many other aspects of capacity to learn will be considered in other working papers, e.g. FOCUS ON PROCESS SKILLS. However, one other aspect of capacity which needs to be considered further in this paper is the milieu, or environment, in which the learner finds he is learning or trying to learn science. The helpfulness or otherwise of the teacher has been commented on in the FOCUS ON THE TEACHER.

65/4/1 Then there is the helpfulness or otherwise of fellow classmates,

7/3/2 "Rather than ask the teacher you would ask a friend or relation."

[ex-pupil]

22/16/1 "we would have got more done if she had done [an experiment] up the front because half the experiments we did in the 3rd form didn't come out anyway because half the jokers in your group would have been mucking around...you need really strict teachers in the 3rd form."

[Form 5 pupil]

43/6/2 "I didn't try [in Science] because I wasn't going to get anywhere in it. There were a few fellows who wanted to do it [learn] but I distracted them sometimes....there were a few fellows like me...they kept on being sent out of the class and that just for mucking around and throwing things around and all that in class."

[ex-pupil]

12/2/2 "I didn't like mucking around with chemicals...acids and things we were always being told they'll burn you and you know and people would chuck them around when the teacher was out of the room."

[ex-pupil]

15/11/3 "in a large group you have several people working so..you know.. and its a bit of a fight over who does what...I didn't fight... but sometimes you are working with someone and they want to do everything and its a bit of a hassle and you miss out on something ...they do something you don't realise and you miss out on an important step."

58/2/2
26/1/2
28/20/1
24/6/1
8/2/2
23/8/1
21/14/2
21/9/1
18/3/2
9/4/1
18/2/1
35/5/1
6/22/2
18/1/3
25/10/1
18/8/2
23/6/1
25/10/3
17/3/2,

[ex-pupil]

In this section we have detailed some of the problems that children have as learners in our science classrooms. Teachers we have talked to have tended to reinforce many of the views expressed here by children and ex-pupils. They have expressed concern at the problems students face with abstract ideas and complex experiments. They have mentioned how difficult it is to get children to think. They have referred to children's inability to follow simple instructions, lack of reading ability, lack of practical skills, and lack of practical experience - all of which represent a background deficit affecting children's readiness to learn science concepts and skills.

MOTIVATIONAL FACTORS

We have already pointed incidentally to some of the factors which, according to the learners themselves, affected their approach to science lessons. Probably the most important, in the long run, relates to differences in expectations between teachers and learners. Some teachers appear to be concerned mainly with teaching science knowledge and skills with the purpose of expanding children's experience of the world and as a preparation for more systematic studies in the separate sciences later [see FOCUS ON THE TEACHER]. Others say they are mainly concerned to foster attitudes of scientific interest and enquiry. What most of the learners say they wanted to do - and what they thought science was all about - was finding out for themselves about the real world. Where these expectations were not fulfilled, pupils and ex-pupils reported a rapid falling off of interest.

41/8/2
61/10/3
43/2/2

Much of what they were being taught seemed to many learners to be trivial and to lack relevance to everyday life.

13/5/1

> "If we had done things in class that related to what happened everyday that would have made it a lot more interesting."
>
> [ex-pupil]

16/12/2

> "They related it to things that you wouldn't think of, that don't really come into your life."
>
> [ex-pupil]

and they couldn't see the point of what they were doing.

12/8/2

> "I can relate to Biology more...to things around really...I mean things like in Physics how when we push something and it hits something else off the end well O.K. so it does it...well so what?"
>
> [ex-pupil]

12/8/2
13/5/2
16/12/3

Many of the examples children have cited to us as aspects of science that they considered were not relevant to their world, e.g. bodies falling off walls, bodies colliding, and light passing through prisms, suggest that the problem may often be that the relevance is not made clear rather than that the topics are intrinsically irrelevant to the pupils' world.

24/14/2
15/10/1
11/1/2
15/1/2
22/13/2

On the other hand, what have pupils found really worthwhile and have motivated them? As mentioned previously, pupils want to find out for themselves and be involved.

7/2/3

> "I prefer to work by myself..I think you are probably getting more when you are having to do research for yourself and really think for yourself."
>
> [ex-pupil]

Possibly the clearest insights in respect of motivation and practical work came from a Form 6 pupil looking back over her science learning experiences:

36/9/1

> "You've got to feel when you finished you've achieved something and if you hadn't been there the results couldn't have been got. It's got to be a really personal thing when the person involved..have enough equipment for every person at least...don't have these big groups of 3 or 4...because somebody always ends up sitting around doing nothing."

74/8/2

Not only therefore do children want to find out for themselves

7/5/2

and want to feel involved but they need to have success experiences and a feeling of achievement.

15/10/2

> "The way we did it was really good...we would take our ticker tape and cut it up and make a graph out of it...I learnt a real lot from that because it sort of showed you what you did.. that was an incredibly good experiment...it stands out in my mind today because I remember I learnt quite a lot from that... because we had a real good teacher too."
>
> [ex-pupil]

Another example of the importance of success, albeit minor success, is provided in Appendix 3. Teachers too have commented on the need for

79/3/2

children to have success experiences.

17/8/2

> "Work needs to be within the pupils' capabilities so then they gain success...they develop the right attitude toward the subject. I really feel that you have to lead them along in the subject..it is so easy to produce barriers and I think produce failures in a subject...I think if teachers go out of their way to make sure the work done is within the range or the capabilities of the pupils, then the interest will follow, providing they can always see to the relevance of the work being done."
>
> [secondary teacher]

CONCLUDING REMARKS

In this paper we have attempted to reflect comments from the pupils and particularly ex-pupils about F1-4 science. Undoubtedly children's initial expectations are high...we have observed a Form 1 class being told "Science is exciting"... Also expectations are of doing science, of activity and of finding out for oneself. Reality on the other hand is somewhat different; there is a lack of activity in many classrooms; many pupils can't see the purpose or relevance of the aspects of science they are asked to study and where there is activity it is often not really directed in a clear way, according to the pupils, into real investigation..."we did things but we didn't learn much."

What are the problems? There are difficulties of pupil capacities to cope with the task. Aspects of science are perceived as being difficult and involving mathematics, equations and formula. Technical words are used and their meanings are not clear. Textbooks are not easy to read and understand. The experiments are sometimes complicated and pupils get lost. It is also hard to learn when half the class just want to muck around anyway. Admittedly this is the negative side of the coin but it reflects many of the comments we have heard.

In fact, it appears that much of what we have been trying to teach children is felt by them to be just "book-learning" - just another set of disconnected tasks imposed by teachers for little apparent reason. In our paper on EXPERIMENTS, we have pointed out that much of the practical work undertaken in science lessons seems confused in its aims : demonstrations are presented to children in the form of experiments or investigations - but pupils are nevertheless expected to produce the "right" result - and genuine investigations occur only infrequently. Such confusion of methods may well be counter-productive in promoting scientific habits since the comments of many children show that they have sensed the intellectual dishonesty of the situation.

Furthermore, many children consider that they are expected to cope with terminology, abstract ideas, models, levels of hypothesising and generalization beyond their capabilities. There has been a downward push in syllabuses, school textbooks and curriculum guides which, for example, introduce scientific terms - often labels for quite complex and subtle concepts at earlier and earlier age-levels. Not only are there known individual differences in ability to comprehend abstract ideas but there are apparently developmental thresholds below which it is unlikely that children will succeed in grasping these ideas. Our efforts to develop scientific knowledge may be counter-productive if embarked on too early because they lead to bewilderment for many children.

The importance of teacher attitude, inevitably reflected in teaching behaviour, cannot be overestimated. We have observed enthusiastic teachers with limited science backgrounds appearing to achieve much through their motivational influence. Our learner comments have shown

that children quickly recognise the degree of involvement of their teachers in what they are doing in teaching science, and respond accordingly. (This could be particularly important in the Intermediate School context.)

There are also difficulties in motivating children which are not unrelated to the question of their capacities in relation to the material they are expected to learn. There is a need for pupils to feel that they are succeeding and for them to see a purpose in what they are doing. They do want to find out for themselves and is this so different from what teachers want? Is it possible in a class of 30 with minimal financial resources and equipment to devise ways of genuinely involving every child in purposeful and fruitful endeavour?

We would not wish to minimize the difficulty of laying an adequate foundation of facts, concepts and skills which may be used either in later everyday life or as a basis for further study. However many ex-pupils we have talked to - and we have attempted to cover a wide range of people - do not appear to have been left either with a really healthy interest in science nor with a belief that they have learnt much of long term significance.[1]

Finally, there appeared to be very little discrepancy overall between the perceptions of teachers and learners about what was actually happening in science classrooms. While this can be considered gratifying in many ways, it is also rather disturbing because particularly in terms of long term goals there seems to be many inadequacies in our teaching and learning of science. As teachers, we do not yet seem to have been able to harness the inquisitiveness of the younger child and direct it into the more systematic mode of inquiring which is basic to scientific thinking and knowledge - at least, as far as many of our adolescents are concerned. Are we clear about our aims, and do pupils recognise them? Until we all know where we are going it is difficult to agree on how to get there.

---

[1] Some of our present work suggests that this belief may well be justified at least in terms of certain basic concepts!

In this paper we have concentrated on the problems and difficulties of the learner and in so doing have not made comment on many positive aspects of teaching and learning science in schools. No doubt some pupils and ex-pupils are well satisfied with their school science experience. However, the consensus of those we have talked to does not reflect any great satisfaction. Have the particular people we have talked to led us to overstate the problems and difficulties of the learner? We will be interested to receive your comments, based on your experiences.

ACKNOWLEDGEMENT

We are grateful to all those people who so freely talked to us about F1-4 Science. We also wish to thank the teachers and pupils who so willingly allowed us to join them in their classroom activities.

APPENDIX - A selection of extracts from the interviews.

1. On expectations - George enjoys dissections

George was a quiet boy sitting in the back corner of a 4th form class. The interviewer had been in the class all period and sat down alongside George, who was working by himself.

Interviewer: What is the best thing you do in science?

George : Chemistry and dissections

I : What have you dissected this year - anything?

G : No not yet...we have been doing a bit on the body and digestion, and we are going to dissect a hare in a week or two.

I : You are going to do some in a week or so?

G : Yes

I : Sort of interesting is it?

G : Yeh, quite good.

I : Did you dissect anything last year?

G : No, we didn't get onto that.

I : Did you do any at primary school?

G : No

I : So you reckon dissection is pretty good although you haven't done any yet?

G : Oh, I've read a lot about it.

2. On capacity.."we see what it says [but] we don't understand it."

The participants are two fourth form girls working together in a science classroom. The teacher gives a brief talk about fossil fuels and has on hand appropriate materials which he displays while he talks. Students are then asked to read a section of a textbook and copy out and complete some completion sentences at the end of the chapter.

Observer : Do you find this work easy or hard?

Mary : Bit hard

Joan : Yes

O : Is the book quite hard?

M : Oh the way they explain it sometimes, the words they use.

O : What sort of words do you have trouble with?

J : Oh the way they explain it...they don't get to the point.

O : You would prefer simple books?

J : All we know is that we are writing down that...and writing the answer in between...we really don't...

M : We just look there [in the text] and we see what it says.

[Mary indicates that they look for a sentence containing the words without real understanding]

J : We don't understand it.

3. On success - the day John got the right answer

John is a Maori boy from a small bush village on the East Coast. He boarded for five years in a medium-sized town for secondary schooling and recently moved to the city to gain work. John works in an unskilled job found for him by the Labour Department.

Interviewer : Did you enjoy school?

John : I liked school in general but I didn't like science not one bit.

I : Can you think why you didn't like it?

J : I couldn't understand it...I couldn't click on science.

I : Any times that you remember you quite liked?

J : I enjoyed the parts I sort of understood.

I : Anything else you liked?

J : Well the bits I didn't like was how to get all these equations...and you had to work them out or something and I couldn't work those out... and I just stopped completely and didn't take any interest.

I : Was there one good moment in science that you really did feel that it was worth doing and that it was good?

J : I think it was when I got one answer right.. and I was the only one in the class who got it right.

I : And what was that about, can you remember?

J : It was one...everyone couldn't figure it out and I just...it was the best part I remember.